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ABSTRACT

Adopting technology to people and examining projects through the eyes of those concerned are two ways new technology and engineering can be installed and successfully operated under the adverse conditions of northern Canada and in the face of predicted labor shortages in the 1980's. Adopting a more flexible technology provides the opportunity for people, not machines, to improve productivity and performance. It increases the quality of working life, significant in the north where southern workers typically experience four stresses leading to high labor turnover: isolation; lack of stimulation; unfamiliarity; and loss or diminution of normal relationships. These stresses can be reduced and workforce stability increased by designing projects from the workers' point of view, using such techniques as selling the experience of working in the north, having workers arrive in groups, hiring women, reinforcing normal social roles, and "freight-equalizing" the culture. Once stress is reduced work schedules and average stays on the project can be extended. Project policies and specifications which include human, social, cultural, and environmental aspects along with economic, financial, and technological factors may prove to be the lowest-cost solutions in the long run, requiring the most advanced technology and engineering available. A brief bilingual (French-English) abstract is included. (SB)

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IN THE ARCTIC

L'INGÉNIERIE DES MATÉRIAUX
POUR L'ARCTIQUE

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ARCTIC ENGINEERING -THROUGH HUMAN EYES

L'INGÉNIERIE ARCTIQUE DANS UNE PERSPECTIVE HUMAINE

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SUMMARY - LE SOMMAIRE

ARCTIC ENGINEERING - THROUGH HUMAN EYES

Technology and engineering are likely to be best used to the extent that specifications for projects include the human, social, cultural and environmental aspects with the technical, economic and financial factors.

This paper discusses the effects of the labor shortages and turnover in the north, in the light of the four sources of human stress - isolation, unfamiliarity, lack of stimulation, and loss of normal relationships. It suggests ways of diminishing such stresses, which can best be achieved by looking at projects through the eyes of those concerned and by adapting technology to people.

L'INGÉNIERIE ARCTIQUE DANS UNE PERSPECTIVE HUMAINE

Il est probable que la technologie et l'ingénierie seront le mieux utilsées jusqu'au point que les normes de projets comprennent les aspects humains, sociaux, culturels et environnementaux avec les facteurs techniques, économiques et financiers.

Dans cette communication, on discute de l'influence du manque de main d'oeuvre et du renouvellement du personnel dans le nord à la lumière de quatre sources de stress humain: l'isolement, l'étrangeté du milieu, le manque de stimulation et la perte de relations normales. On propose des moyens de réduire ce stress et l'on y parviendra le mieux en examinant les projets du point de vue de ceux qui sont concernés et en adaptant la technologie à l'homme.

ARCTIC ENGINEERING - THROUGH HUMAN EYES

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Under what conditions can technology and engineering be maximized?

Well-engineered projects are technically sound, economic, and safe. Today we increasingly require that new technology and engineering be compatible with the environment, and that the interests of the human beings and groups involved be taken further into account. Under southern conditions, there is no difficulty in doing this, so long as all the requirements are genuinely included in the project and specifications at an early enough date;[1] but in Canada's mid-north and far-north, the situation is more difficult. Conditions are adverse; it is difficult for human beings to operate with the same efficiency as in easier climates; personal problems increase; turnover rates are high, leading to high costs. Large projects disrupt small communities; the ratio of southerners to northerners may, usually does, change abruptly, leading to further long-term social problems; and the supply of labour may diminish in the eighties.

There are, therefore, increasing reasons for looking at the relationship of technology and people in the North.[2] The purpose of this paper is to present two principles to act as guides in this complex field. These are:

1. Adapt technology *to* people.
2. Learn to examine projects *through the eyes* of those involved.

The concern of this conference is materials engineering under Arctic conditions. The above two principles can be used to enable new technology and engineering to be put in place and successfully operated under the adverse conditions of the North and in the face of greater competition for the supply of labour.

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[1] Simmonds, W.H.C., "Social Environmental and National Criteria for Chemical Projects", Chem. in Can., 26, #11, 21-24 (1974).

[2] MacMillan, J.A., Tulloch, J.R., O'Brien, D. and Ahmad, M.A., "Determinants of Labor Turnover in Canadian Mining Communities", Report #19, Series 2, Center for Settlement Studies, Univ. of Manitoba, 1974.

1. The Coming Labour Shortage

Demographers are warning us of possible shortages of labour in the mid-eighties, which is roughly one research time frame away. In round figures the number of entrants to the Canadian labour force is expected to fall from 240,000 persons per year on average at the present time to 150,000 persons per year in the mid-eighties. Where before we had 3 entrants we are likely only to have a more highly educated 2,[1] assuming current levels of immigration to continue.[2] In the U.S. the same drop is forecast but only from 4 entrants to 3. The Canadian figures are shown graphically in Figure 1 in the form of the number of 15-19 year olds, male and female, from 1931 to 2001.[3]

The drop-off in entrants to the labour force in the eighties is relatively sharp, but its effects on competition for labour for mines, smelters, forest operations, etc. on remote sites is likely to be much more dramatic, since Canada, unlike Denmark,[4] does not grant any tax concessions for working in the mid- or far-north. It may be wise therefore to look at mine requirements in terms of technologies and people, technologies which require southerners, technologies which northerners can master and maintain, technologies which do not require unnecessary people but which also foster and require competence amongst those who control them; and further, working conditions which are compatible with northern ways of living or for southerners who can adapt to the north.[5]

There is a case here for some sensible and pragmatic foresight, which is likely to prove close to the first principle of adapting technology to people.

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[1] Doyle, F.W., Dept. Industry, Trade & Commerce, Ottawa, private communication; Stone, L.O. "Canadian population trends and public policy through the "'80s", Inst. for Res. on Public Policy (in press).

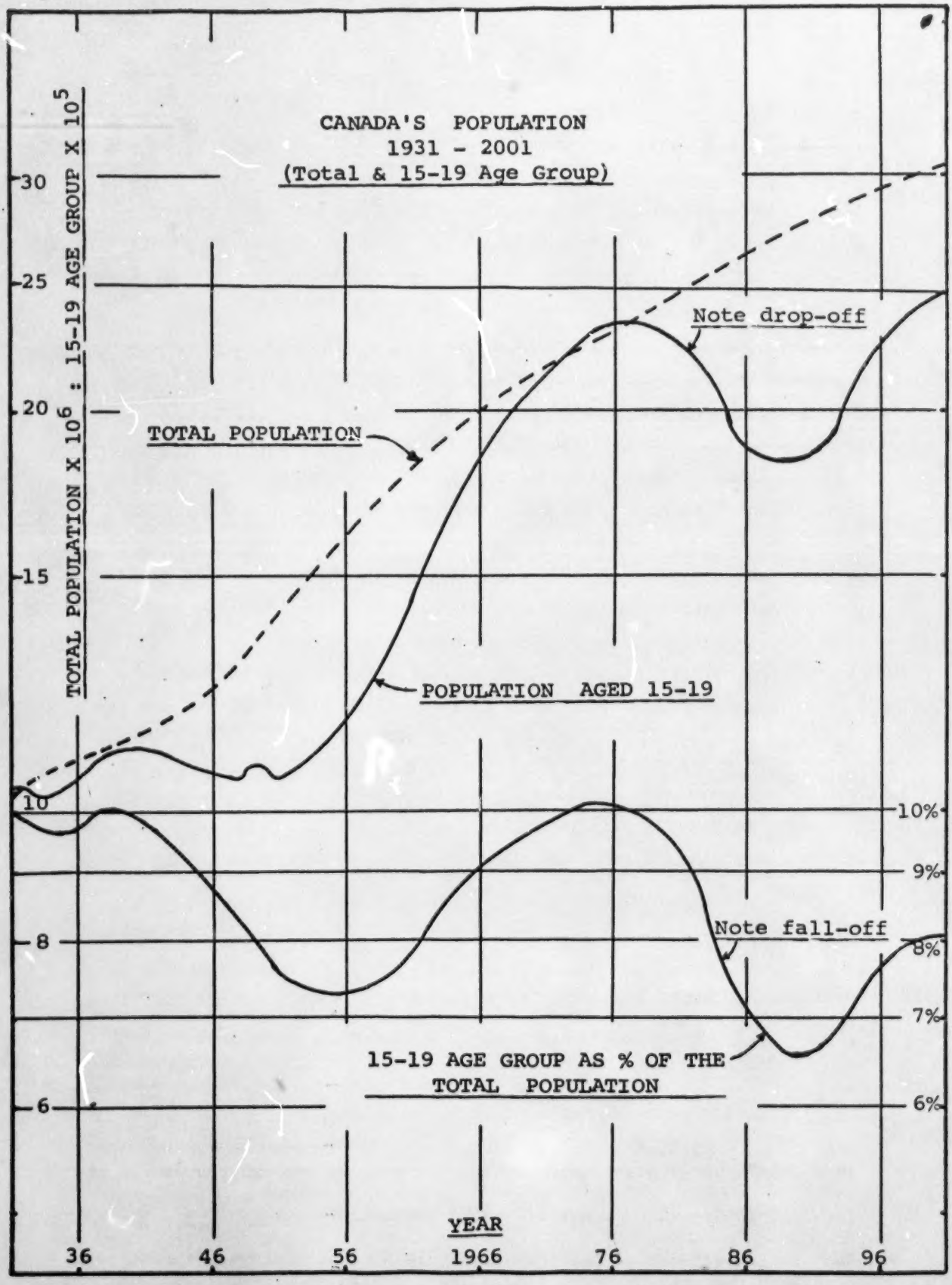
[2] Kelly, F.W., "Population growth and urban problems", Science Council of Canada, Perceptions One, 1975.

[3] Stat. Can. 91-514, "Population projections for Canada and the provinces 1972-2001", 1974; Stat. Can. 91-512, "Population 1921-1971", 1973.

[4] Earnings in Greenland are tax-free in Denmark.

[5] Some of the effects of the economic cycle and labor shortages have been described recently by Gray, R.M., "The Canadian Mineral Drilling Industry - Its Problems and Its Future", CIM Bulletin, 68, #759, July 57-64, (1975).

Fig. 1


CANADA'S POPULATION
1931 - 2001
(Total & 15-19 Age Group)
TOTAL POPULATION X 10^6 : 15-19 AGE GROUP X 10^5
30
25
20
15
10
8
6
TOTAL POPULATION
Note drop-off
POPULATION AGED 15-19
10%
9%
8%
7%
6%
Note fall-off
15-19 AGE GROUP AS % OF THE TOTAL POPULATION
YEAR
36
46
56
1966
76
86
96

2. Adapt Technology to People

For three-quarters of a century we have been adapting people to technology. The thrust of Taylorism and automation was simple;[1] the more closely men behaved like machines, the greater their efficiency and productivity would become. Charlie Chaplin pilloried this concept in his film, "Modern Times"; automation reached its reductio ad absurdum when workers refused to work in the most completely automated auto plant in the world at Lordstown, Ohio.

What went wrong? Put in a nutshell, it was the increasing absurdity of earning higher and higher real incomes by work which required less and less human contribution, thanks to the technologies of automation and the economies of scale. This has led to the demand for work which needs and requires human intervention and contribution, in which technology aids and assists people instead of dominating them. We are thus reaching the point where the diminishing gains in increasing scale of operations can begin to be offset, or even overtaken, by gains in human productivity. The critical point is the mental switch from thinking that here is the technical solution and people had better accept/like it to the opposite pole of here are people and how can we enable them and us to win by means of appropriate technologies.

The emphasis has thus began to shift from *scale* and the *rigidity* of technology to a renewed interest in different *kinds* of technology and *their flexibility*.

This is not new. Machine tools were once highly specialized for specific, and sometimes single,duties. Today, the multi-purpose, tape-controlled machine is common, and if there are problems, they lie in a lack of ability to fully exploit the capabilities of such machines.

Thus, to increase productivity, improve performance, and lower costs, the human being ranks high as the best bet to bring these about in the seventies and eighties. But do we know how to do this? And the answer at the moment is sometimes!

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[1] Taylor, F.W., "Principles of Scientific Management", Harper, 1911.

3. QOWL, etc.[1]

There are many names for it - job satisfaction, work improvement, quality of working life (QOWL), making work more satisfying, humanness-in-living (HIL),[2] etc. In the U.K., as an example, the Work Research Unit was recently set up as a tripartite body composed of the U.K. Dept. of Employment, the Federation of British Industry, and the Trades Union Congress. This unit has summarized all the cases where attempts have been made to "humanize" work. They found success in some cases but not in others, but what was more curious, that where there was success in one unit or part of a company, it did not necessarily spread elsewhere in the same unit or company. We are thus at the point where we know that work can be conducted in quite different ways, that the change from one kind of working to another is tricky, and that we do not yet know the criteria for success.[3]

What then can engineers, scientists and technologists do about it, if anything?

4. Through Human Eyes

Fortunately there is one simple test which designers can make in regard to the human situations in projects, that is, to examine them *through the eyes of those involved.* Such an exercise forces management to look at, not just *what* is being done, but *how* it is being done.

Consider, for example, arriving at work. If this is done by being collected by the company bus, it may be cheap but the human being arrives at work as an isolate at a time, and in a way, set by someone else and over which he has no control. If he drives his own-car,at least he arrives under his own volition, i.e. as a person in his own right.

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1 Wilson, N.A.B., "On the Quality of Working Life", London, H.M.S.O., 1973; Labour Canada,"Measuring the Quality of Working Life", Information Canada, 1973.

2 Simmonds, W.H.C., "Social Criteria: Aid to New Decision-Making", The Business Quarterly, 38, #2, 32-37 (1973).

3 Work Research Unit, "Improving Satisfaction at Work by Job Redesign", Report #1, S. Cameron et al, May, 1974.

If he arrives in the town (community-owned) bus or shares a car-pool, he arrives as a member of a group, no longer as an isolate. Thus, there are profound psychological differences even in such a simple example as that of getting to work. These are exacerbated as conditions become more adverse. And the psychological frame of mind with which a person starts a day colors his/her productivity, safety, quality of work, responsiveness, responsibility, etc., and in due course helps to build up the determination to get out and never return, or to stay and make a go of it.

The key to the individual's reaction in this case is his *perception* of the situation and how it relates to himself, or to his *sense-of-being*.[1] When a proposal or change is put to a person, his/her reaction to it can be judged, not so much by what they say, as by their body-language response. If the proposal enhances someone's sense-of-being by making them feel more of a person, by reinforcing their humanness, by recognizing them and their contribution, it shows; conversely, a proposal which does the opposite may be accepted in words but the body-language reveals the impact of being treated as disposable, unimportant, convenient, etc., the diminishment of one's sense-of-being. To discover what these reactions are likely to be, it is only necessary to step into the shoes of the person or group concerned, look at the proposal through their eyes and record whether one's sense-of-being is affected positively or negatively. In many cases it may then only require a change in *how* the project is carried out to convert a negative reaction to a neutral or positive one. No one can win every battle, but designers can seek a net overall gain and, in particular, to identify the crucial points in their projects from the human point of view. Hindsight suggests that this has not always been done in the past!

We have ignored the north in this part of the argument. What additional effect does that have?

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[1] Simmonds, W.H.C., "Bridging the Chasm: the Next Stop", Tech. Fore. & Social Change, 6, 267-276 (1974).

5. The Stress of the North

The three stresses which a southerner experiences in the North have been identified as:[1]

(i) the felt isolation;

(ii) the unfamiliarity, and

(iii) the lack of stimulation.

Each of these is highly negative, for most southerners, i.e: they reduce or lower their sense-of-being. These effects have been studied most thoroughly by the National Aeronautics and Space Administration (NASA) in the U.S.,[2] since the dangers of psychological breakdown due to prolonged stress in the confined quarters of a spacecraft on deep space missions (>1 year to Mars, for example) are known to be very real. The main findings can be very briefly summarized as follows:

(a) psychological factors are, in general, more important than physiological factors;

(b) emotional stability, social compatability with, and leadership within, the group are essential;

(c) work is preferable to 'spare' time; it should be sufficiently challenging to reduce monotony and boredom, but must not exceed the maximum level of capability under the actual Arctic (or spacecraft) conditions when allowance is made for possible deterioration in performance or for emergencies;

(d) a person's normal roles of husband/wife, father/mother, parent, counsellor, amuser, confidant. participant in community, sports, hobbies or other affairs, etc., should be maintained to the extent possible;

(e) for some people, knowledge of the aims and objectives of the project and its progress is valuable.

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[1] Zrudlo, L., "Psychological Problems and Environmental Design", Conference on Building in Northern Communities, Université de Montréal, May, 1973, published by the Arctic Institute of North America, pages 118-126 (1974).

[2] Vinograd, S.P., "Studies of Social Group Dynamics under Isolated Conditions", NASA Contractor Report CR-2496, prepared by the George Washington University Medical Center, Dec., 1974.

The above findings suggest that we should add a fourth item to the list of negative factors to working in the far North, namely:

(iv) loss, or diminution, of normal relationships.

With the increase and improvement in telecommunications in the North, the ability to maintain contact with relatives, friends, families, and girl or boy friends should be becoming more feasible.[1] A more complete description of the NASA findings is given in the Appendix.

6. A Different Approach

The remarks made earlier suggest a new approach to the question of increasing the stability of workforces in the North, by designing from the inside → outwards, i.e: looking at the problem from the point of view of those involved, or looking through their eyes.[2]

When this is done, a number of new possibilities begin to emerge, or, in different language, the priorities change.

I. Sell experience, not work

In 1958 Mr. Diefenbaker revealed that there was a great latent interest in the North among Canadians, but few could get there, or afford to do so. It is thus possible to sell x months in the mid- or far-North as an essential lifetime experience for all Canadians. Come and see it, find out what your own country is really like, work part of the time to earn money and pass some of the time, but look around, do what you would like to do and make the most of your stay in the North.[3]

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[1] Long distance phone calls to friends and families may be a better investment with more rewarding pay-offs for human beings than lobster or steak for the nth time.

[2] cf. the seminars on "People and Work in the Mineral Industry", Dept. of Mining & Metallurgical Engineering, McGill University, Montreal, Nov. 3-5, 1975, and on "Isolated Communities and the Mineral Industry", Oct. 6-8, 1975.

[3] The writer has called this *"charterwork"*. It utilises the tourist industry's approach to vacations through charter flights; Simmonds, W.H.C., "Design Criteria for the City of Athabaska", The National Design Council Project N.R.C., Ottawa, Nov., 1974.

Not all youngsters wish to sign contracts for several years in the North; if companies aim for a longer employment period than workers really want, the contract basis is false and turnover costs and labour shortages will surely rise.[1] A more realistic balance between the interests of both parties offers the chance of an increase in the time spent in the North per person and lower turnover rates. If accommodation to the interests of workers will become inevitable,why wait till then?

II. Arrive in groups!

In their report to the National Design Council's study on Design Excellence, the University of Calgary study team emphasized the value of people arriving in the North as groups, rather than as isolates.[2,3]

If you can, recruit friends, or groups from the same neighbourhood or similar backgrounds; if possible, let them meet in a party before taking off in the Boeing 737 so that they arrive on a first-name basis; see that they are met by "similars" and, obviously, that appropriate accommodation is available. Most of us like a welcome under southern conditions. Is a welcome more or less needed in the North?

III. Girls can work too!

The most effective way to keep a young man in the North is still a girl, but the under 30 sex ratio is very unsatisfactory in most mining communities.[4] Companies have been discovering that girls can handle heavy equipment; more women are now willing to work in a wider range of industries; and servomechanisms are making this more possible.

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[1] In its 1974 Annual Report, the Mining Association of Canada speculated that, in 1974, total labor turnover and shortages could cost the industry $350 million; this includes $50 million for the hiring and training of new employees plus an 8% reduction in the output of the industry attributed to labor shortages.

[2] The Research Unit, School of Social Welfare, University of Calgary, "Human Aspirations and Design Excellence", Jan., 1975. One potential source of employees are those whose families have been split apart by the welfare regulations in certain American states and the U.K., which require the father to leave the family. Such families could be reunited in Canada.

[3] National Design Council", Design Excellence - A National Objective", Assembly Summary Report, Ottawa, 1975.

[4] Lajzerowicz, J. et al, "Mining Communities in Canada", Dept. of Energy, Mines & Resources, 1974.

IV. Reinforce identities.

The excision of normal social roles hurts. Suddenly one is no longer a husband or father; men and women become concerned about their girl or boy friends elsewhere. The effects of cutting normal social ties appear to be underestimated. The NASA work, for example, does not emphasize the importance of maintaining these social roles in deep space flights. There appear to be opportunities here.[1]

V. Freight-equalize culture.

This is a more controversial area. There are obvious reasons for 'freight-equalizing' the FM culture in the same way as electric power and the telephone. Cable networks seem to be essential for the coming electronic age of the eighties. The present penalties in living outside the range of FM stations in cities encourages more urbanization, which many people believe to be unnecessary and highly expensive. On this basis cable FM should follow telephone or satellite communications into the North at incremental cost, to help to reduce the feeling of isolation and separation from the known.

This view is opposed by those who wish to enjoy the North as it is, without juke boxes, garbage, and noisy internal combustion engines.

There appears to be room for both points of view in any but the very smallest settlement.[2]

VI. Knit the community together.

The design of northern communities on conventional North American lines makes little sense. At least some parts of a community should be designed to bring people in close proximity by means of townhouses or apartments. Moshe Safdie has outlined how this could be done in his proposal for Frobisher Bay.[3] The subject of community design and its effects is not followed up here, but continues to receive attention.[4]

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[1] Kunkel, J.H., has examined the possibilities of psychological reinforcement in economic systems in his book, "Behaviour, Social Problems, and Change", Prentice-Hall, 1975.

[2] One of the interesting design requirements for homes or apartments in the North is that they must provide more privacy and more togetherness than in the south! University of Calgary, loc. cit.

[3] Proposal for "The Replacement Staff Housing for Frobisher Bay", Nov., 1974; National Design Council exercise "The Frontier Community" in Design Excellence - A National Objective, Ottawa, 1975.

[4] For example, the Habitat 76 Seminar, Yellowknife, N.W.T., Sept. 1975.

It will be clear from the above that work schedules represent the balance between the opposing driving forces of the desire for money versus the four negative stresses given in section 5 - isolation, unfamiliarity, lack of stimulation and cut-off from normal social roles.

By reducing these stresses, work schedules could be lengthened or the average length of stay in the North increased, but an upper limit is set by the monotony of the surroundings and repetitiveness of most work, especially during the period of winter darkness.[1] The Russians, for example, pay up to 2½ times Moscow rates and transport workers from a city as large as Norilsk(70°N) to Yalta for a break during the period of total darkness. For regular work in the Canadian Arctic, work schedules may vary from 18 days on, 10 off, for drilling, to 21 on, 7 off, during the winter to 14 on, 14 off, during the summer. Work schedules on a one-shot basis are tougher, e.g. 6 months every four years for the Canadian Armed Forces at Alert, 12 weeks on, 1 week off, for the Alaska pipeline currently being constructed.

At the present time, schedules have been arrived at from experience. The way may now be open to a more careful enumeration of the different factors which affect them, with more satisfactory results for all.

8. Summing-up.

This paper has emphasized the integral part which human beings and the conditions under which they work, play in the development of materials engineering in the Arctic.

It is encouraging to report that such an attitude is being built into new mining ventures in the North, such as the Strathcona Sound project on Baffin Island.[2] This represents a serious attempt to integrate technical, industrial, economic, and social objectives within a thought-out set of northern policies.[3,4] 60% of the workforce, for

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[1] Southerners usually find the reversal of the best working time in the year from summer to winter difficult to adjust to. See Schindler, J.F. "What's It Like to Live and Work in Arctic Alaska?", Pipeline & Gas Journ. July, 42-58 (1974).

[2] Yates, A.B., "Nanisivik - An Example of Government-Industry Cooperation in the Far North", CIM Bulletin, 68, #762, Oct., 71-78 (1975).

[3] Dept. of Indian & Northern Affairs, "Canada's North 1970/1980", Ottawa, '72.

[4] Walsh, A.R., "Mine Development in the High Arctic", CIM Bulletin, 68, #761, Sept., 91-96 (1975).

example, will be Inuit, but in a manner which takes into account their traditional lifestyle and the expected life of the mine. Agreement has been obtained from customers of the mine, financiers, the producing company and government, with government holding an 18% equity interest in the company in return for the infrastructure provided. The future will show how well the results will match the intentions; the important point at this stage is that this wider approach and planning has begun.

The complexity of Northern projects and of policies for the North is not to be underestimated;[1] but it still appears to be a sound bet that policies and specifications which include the human, the social, the cultural, and the environmental, may well prove to be the lowest cost solutions in the long run; and one reason will be that *meeting specifications which include the human, the social, the cultural, the technical, the economic, and the environmental will require the most advanced technology and engineering.*

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[1] Keith, R.F. et al, "Northern Development and Technology Assessment Systems", Science Council of Canada Background Study #34, Ottawa, Jan. 1976.

APPENDIX

"Studies of Social Groups Dynamics under Isolated Conditions", NASA Contractor Report CR-2496, prepared by the George Washington University Medical Center, Dec. 1974.

This report summarizes and compares the results of 81 studies on negative environments such as the Arctic, the Antarctic, submarines, space flight simulations, fall-out shelters after a simulated attack, underwater habitats, coal mine disasters, imprisonment, mountain expeditions, etc.

In the majority of the situations or tests, spirits are high at the start, drop during the period of unusual conditions and rise towards the end of it. The more highly trained and motivated a person by professional or military standards, the better he stands up, but monotony and boredom exact a toll from all. Overt displays of anger or hostility are relatively rare; feelings are driven inwards and tensions directed outwards towards those held responsible for the situation. Competitive games, for example, may be avoided in confined situations (simulated spaceships), and work is preferred to free time. Good leadership assists the individual to integrate into his group.

Constructive actions include: eliminating the emotionally unstable and socially less compatible (preferably from the start); maintaining an open 'loop' with the normal world, publicly in terms of TV, music, news, sports, etc., and privately in terms of the normal social roles of a man or woman which would otherwise be cut off (as parent, home-teacher, confidant, amuser, and, to the extent possible, lover); reinforcing the individual's sense of personal identity and belonging to a larger cultural identity; structuring and varying the balance of work versus free time to challenge the individual enough to prevent monotony and boredom, but sufficiently below his maximum level of capability to allow for possible deterioration in performance or for emergencies; articulating the objectives and goals of the project and progress towards them.

The basic finding is that psychological variables are generally more influential than physiological variables; or as one observer put it, "the deckhands and captain of the barge actually were throwing uneaten steak and lobster overboard as they were leftover and they had become

tired of this diet of delicacies."[1] The trade-off was between food and contact with one's family. When she interviewed the captain, her comment was that "it was most evident that the separation from his family (approx. 4 months) was difficult, but he earned enough money in the North during the summer to last him during the winter months in the South."

As the NASA study notes, we have far too little usable information on practical problems such as "techniques for selecting personnel for optimum group harmony and effectiveness, selection of leaders, early identification of disruptive trends, recognition of disruptive factors, preventive methods, and corrective techniques." This in turn requires knowledge of "the nature and dynamics of small group function, the roles and relationships of individual members, and the kinds of changes that occur over time" under adverse or unusual conditions.

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[1] Paula Luck, personal communication, Dept. of Engineering, Queen's University.